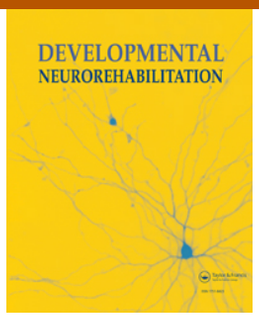

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BRIEF REPORT

A microcosting study of the surgical correction of upper extremity deformity in children with spastic cerebral palsy

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ABSTRACT

Objective: Determine healthcare costs of upper-extremity surgical correction in children with spastic cerebral palsy (CP). *Method*: This cohort study included 39 children with spastic CP who had surgery for their upper extremity at a Dutch hospital. A retrospective cost analysis was performed including both hospital and rehabilitation costs. Hospital costs were determined using microcosting methodology. Rehabilitation costs were estimated using reference prices. *Results*: Hospital costs averaged €6813 per child. Labor (50%), overheads (29%), and medical aids (15%) were important cost drivers. Rehabilitation costs were estimated at €3599 per child. *Conclusions*: Surgery of the upper extremity is an important contributor to the healthcare costs of children with CP. Our study shows that labor is the most important cost driver for hospital costs, owing to the multidisciplinary approach and patient-specific treatment plan. A remarkable finding was the substantial amount of rehabilitation costs.

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Cerebral palsy; cost analysis; microcosting; surgery; upper-extremity deformity

Introduction

Cerebral palsy (CP) is a non-progressive central nervous system disorder of motor function that is caused by damage to the brain in the fetal or perinatal period. In the last decade of the twentieth century, the prevalence of CP in very low birth weight infants substantially increased. The prevalence of CP in juveniles has risen to about 2.5 per 1000 life births in the 1990s in northwestern Europe.[1] This seems to be attributable to the increased survival of newborns resulting from improved neonatal intensive care.[2]

The most common form of CP is spastic CP, 72%–91% of those with CP, in which children have an imbalance between spastic and paretic muscles.[1,3] Spasticity of flexion and adduction muscles and weakness of extension and abduction muscles often cause upper limb deformities in children with spastic CP. These deformities will significantly affect motor function, resulting in difficulties with reaching, pointing, grasping, releasing, and manipulating objects.[4]

Interventions for improving upper limb function in children with CP include physiotherapy, occupational therapy, peripheral casting, the use of botulinum toxin, and surgery. Surgery consists of releasing or lengthening the spastic or contracted muscles, augmenting the weak or flaccid muscles through tendon transfers and stabilizing the joints as needed. All procedures are typically performed in one surgical session. Although surgery cannot fully eliminate the deformity, it can produce substantial improvements in upper limb function.[5]

Improvement can be realized for children who are selected carefully through complete physical examination, motor and sensory function assessment, and clinical evaluation of impairment of daily life activities.[6] By international convention, this selection is done by a multidisciplinary team consisting of at least a hand surgeon, occupational therapist, and rehabilitation specialist. This multidisciplinary team tailors each surgery to a patient's individual problems and needs.[7]

Healthcare costs of children with CP are 1.8 times higher than those of a child without CP in the USA.[8] The average lifetime healthcare costs of patients with CP are reported to be €860 000 for men and €800 000 for women in Denmark.[9] Treatments for children with the spastic type show the highest costs, due to the fact that surgical procedures are frequent in these children.[10] Of these surgeries, Murphy et al.[8] showed that soft-tissue musculoskeletal procedures are the second most frequently performed, after gastrostomy tube insertions, and accounted for US$ 11 445 (EURO 2014: €11 540, converted with purchasing power parity (PPP)[11]) per patient.

Costing studies are a prerequisite for registration, reimbursement, and pricing of hospital services in many countries, because they can provide healthcare decision-makers with valuable information on the relative efficiency of different services.[12] For costing studies, the microcosting approach is seen as the gold standard method, because it allows for the identification of costs per individual patient and for insight into patient subgroups that might have a great share in the total costs. As this methodology is time consuming, it has not been widely used in assessing costs in the CP population.[13]

The aim of this study is to calculate healthcare costs of the surgical correction of upper-extremity deformity in children with spastic CP using the microcosting approach. Health care costs will include both hospital and rehabilitation costs.

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Method

This microcosting study was performed in conjunction with a clinical trial. More details of the study design can be read in the clinical results paper published in 2015.[14] In short, all children with spastic CP who had surgery for their upper extremity between April 2003 and April 2008 at the Academic Medical Center (AMC) in Amsterdam were included. When complete data on resource use were not available from the hospital information system, the patient was excluded. Given the retrospective nature of this cost analysis and the absence of direct patient contact, no approval of the research ethics committee was necessary.

This retrospective cost analysis is performed from a healthcare provider's perspective, including hospital and costs of the rehabilitation program after the intervention. All costs are based on Euro 2014 cost data. Where necessary, costs were adjusted to 2014 using the general price index from the Dutch Central Bureau of Statistics.[15]

Hospital costs

Hospital costs consisted of medical costs from the first contact with the hospital, related to the surgery in question, until the last checkup, 9 months after surgery. These costs also include visits to the hospital after admission, such as checkups (assessment of motor function, changing casts, and receiving splints) and medical aids. The microcosting methodology is used to calculate all hospital costs, in which all relevant cost components are identified at the most detailed level.[13] Bottom-up microcosting was used to calculate hospital costs. This methodology is characterized by the identification of patient-specific resource use and hospital-specific unit costs.[13,16] When hindered by the incompleteness of hospital databases, top-down microcosting was accepted, which uses resource use for an average patient and unit costs derived from standard or estimated costs.[13]

Healthcare resource use was identified per individual patient from the patient's file in the hospital information system. This provided an insight into patient specific information, e.g., number of hospital days, type of anesthetic, materials and devices used, complications after surgery, and actions taken as result of these complications. After collecting this data, more details were needed regarding hours of labor, hours in certain rooms to calculated overheads, medical aids and medication received, and devices and materials used during surgery and checkups. This was collected through interviews containing open-ended questions with a hand surgeon, a resident in training for hand surgery, and an occupational therapist. Manufacturers were used as an alternative source of information on durability of equipment and materials.

The following unit costs were collected from the hospital database: admission costs and costs on the ward (inpatient stay), labor (e.g., physicians, nurses, OR nurses, administrative staff), anesthetics, devices, and materials. As approximately 80% of the children stayed at the "Teenagers"-ward and 20% at the "Older Children"-ward, costs of admission and inpatient stay are a weighted average of the costs at these two different wards. Unit costs of labor were expressed in costs per minute, calculated by dividing the normative income by the number of workable minutes a year. Normative incomes were based on collective labor agreements. When not available from hospital databases, unit costs of devices and materials were gathered from the manufacturers. Medication costs and costs of additional diagnostics performed due to complications were calculated with the use of wholesale prices.[17,18] Unit costs of medical aids were collected through interviews with an occupational therapist, orthopedic technician, and manufacturers. The overheads were gathered through an interview with an employee of the housing division and translated in hourly rates for the use of different types of rooms in the hospital. These overheads included costs due to general expenses, administration and registration, power usage, maintenance, insurance, and personnel costs of non-patient services, e.g., management, depreciation of buildings or inventory, and interest.

Bottom-up microcosting could be performed for the calculation of hospital costs concerning admission, inpatient stay, materials used, anesthetics given, and some of the devices used. Top-down microcosting methodology was used calculating overheads, labor, medication, medical aids, complications, and some other devices used.

Rehabilitation costs

The rehabilitation program consists of occupational and physiotherapy. Information on resource use during a rehabilitation of average duration for this type of children was collected through an interview with a rehabilitation specialist. Standard costs for rehabilitation were taken from the cost manual.[19] With this information, rehabilitation costs after the surgical correction of upper-extremity deformity in children with spastic CP were estimated.

Sensitivity analysis

To determine the uncertainty of the obtained cost estimates, one-way sensitivity analyses were carried out by individually varying each unit cost value between 50% and 150%. This range is in agreement to earlier microcosting studies conducted in many other study populations (among others:[15,20,21]).

Results and discussion

Forty children were eligible for this study. One child was excluded due to incomplete resource use documentation; therefore 39 children were included in this study. Table 1 shows the patient characteristics at the time of surgery.

An overview of the unit costs is provided in Table 2. The mean total hospital costs for the correction of the upper extremity in children with spastic CP are €6813. Labor accounted for 50%, which may be explained by the multidisciplinary approach and patient-specific treatment plan. Overhead costs accounted for 29%, medical aids for 15%, and materials and devices for 6% of the total hospital costs.

Table 1. Patient characteristics at baseline.

n	39
Age	12.38 (SD 3.7)
Sex	
Male	64%
Female	36%
5–10 year success rate of surgery	80%

According to the hospital information system, the children stay approximately 3.5 days at the ward during hospitalization. Costs for this inpatient stay are €2773. This includes overheads, labor, equipment, and material and medication costs directly related to the ward. The children are in the operation room for 3.5 h, of which the surgery takes 2.5 h. Before and after surgery, the children spend 2 h on the recovery ward and all operations were performed under general anesthesia. Total costs for surgery were €1345, including labor, anesthetics, material, devices, and overhead costs directly related to surgery and recovery stay. Some developed minor complications or required additional diagnostics, which can be found in Table 2. Also after admission, 10% of the children needed a new scotch cast, which accounts for an additional €20 per child. During admission, resource use of the children was consistent, which accounts for little variability in hospital costs between the children. This may be due to short hospitalization, a small age distribution, few complications, and because all operations were performed by the same hand surgeon (MK).

Six weeks after surgery, a rehabilitation program at a rehabilitation center close to the child's residence was started. All of the children received physiotherapy 2.5 times a week (personal interview with rehabilitation specialist BI, August 2013; unreferenced). Seventy percent of the children received additional occupational therapy 2.5 times a week. Each treatment, physiotherapy or occupational therapy, took 30 min. On average, the total duration of the rehabilitation program was 3.5 months. Standard costs for rehabilitation (physiotherapy or occupational therapy) are €121 per hour,[19] which gives a total cost estimation of €3599 for the rehabilitation process per child. As these rehabilitation costs were roughly estimated, no conclusions can be drawn with regard to aspects that could have influenced these costs, e.g., cognition or the degree of spasticity of the children.

A sensitivity analysis is shown in Table 3. Total costs changed 16% when labor costs and 9% when overhead costs were varied by 50%. The influence of varying the remaining cost components also appeared to be rather modest, namely between 2% and 5% (hospital costs: 3%–7%).

In the Netherlands, the price in 2008 for the Dutch Diagnosis Related Group (DRG)-like DBC-tariff ("Diagnose-Behandel-Combinatie" translated as "diagnosis-treatment-combination") matching this surgery was €5177[18] (EURO 2014: €5762). A DBC can be defined as a predefined average care package with a fixed price for a specific diagnosis and treatment. Payments received by the hospital from insurance companies are based on these DBCs. This difference suggests there was a discrepancy between costs made by hospitals and payment received from insurance companies in 2008. Also the reference price of inpatient stay at an academic hospital was lower compared to our daily costs of inpatient stay—€539[19] versus €792. This difference may be attributed to a difference in hospital care between adults and children, and the costs of inpatient stay may be higher when patients had surgery compared to a hospitalization without surgery. However, Murphy et al.[22] showed average costs of US$ 15 478 (EURO 2014: €15 606, converted with PPP[11]) per hospitalization related to musculoskeletal and connective tissue system disorders in the US (resource use collection was done in 1997), which is more than twice calculated hospital costs in this article. This may be due to the inclusion of more costly operations, e.g., operations on the lower extremities, spine, and hip. Additionally, what contributed to our relatively low hospital costs was the performance of all surgeries by the same experienced hand surgeon, which lowers operation time and therefore the total costs of surgery, the absence of serious postoperative complications and the short duration of hospitalization. This meets the findings of another study of Murphy et al.,[8] in which low rates of complications and relatively brief hospitalizations in musculoskeletal surgeries of the hips and extremities in patients with CP were reported. In our hospital, children are operated on the second day of admission. One day on the ward costs €792 in our study. However, the AMC has extensive clinical experience with the current surgery and postoperative regime, given the high costs of inpatient stay; it would be interesting to know if shorter admission or postoperative therapy will lead to poorer results.

Putting the results in perspective, it is important to know the clinical results of this surgery[14] Clinical improved position of the thumb, 5–11 years after surgery, was present in 80% of the patients. Combined with the costs calculated by this study, the costs per clinical improved thumb position after surgery could be estimated at €13 015. In the article, we stated that to optimize the success rate, careful assessment, selection, and planning before surgery is required.[14] This approach may account for less complications and less failures, which will optimize the cost-effectiveness.

Unfortunately, a reliable cost-effectiveness or -utility analysis could not be performed. A clinical outcome measure (except for thumb position) was not available, and analyzing this did not fit the scope of this article. Also a generally accepted outcome measure for utility to perform a cost-utility analysis, like quality-adjusted life years (QALY), was not available for this population. It is difficult to isolate QALY directly related to upper-extremity function, as children with CP are often coping with more than one disorder related to their illness. This broad spectrum of disorders in CP also makes it difficult to perform a study from a broader societal point of view, due to difficulties in isolating costs made and gains received by the parents directly related to the surgery. For example, out-of-pocket costs from the parents could have been collected from interviews with the parents. However, recall bias would have had a major influence on the answers given the time frame.

Ruiz et al.[23] showed that the use of botulinum toxin in the management of children with CP led to a significant reduction in requirement for surgery compared to their control group. This led to a reduction in the costs of managing a child with CP. However, the studied period was only 1 year and botulinum toxin is a short-

Table 2. Resource use and unit costs (Euro 2014), $n = 39$.

	Resource use	Unit costs	Costs per patient	Information source volume	Cost price
HOSPITAL COSTS					
Diagnostics by multidisciplinary team					
Labor (in min)					
Hand surgeon	45	1.69	76.19	Hand surgeon	Hospital database
Resident hand surgery	45	0.56	25.26	Hand surgeon	Hospital database
Rehabilitation specialist	45	1.64	73.60	Hand surgeon	Hospital database
Occupational therapist	110	0.55	60.07	Occupational therapist	Hospital database
Overheads (in minutes)					
Outpatient clinic by multidisciplinary team	45	0.08	3.79	Hand surgeon	Division Housing
Outpatient clinic by occupational therapist	45	0.08	3.79	Occupational therapist	Division Housing
Total costs of diagnostics by multidisciplinary team			**242.69**	**(SD 33.70)**	
Consult anesthesiology					
Labor (in min)					
Anesthesist	20	1.61	32.20	Hospital database	Hospital database
Overheads (in min)					
Outpatient clinic anesthesiology	20	0.08	1.68	Hospital database	Division Housing
Total costs of consult anesthesiology			**33.89**	**(SD 21.59)**	
Hospitalization					
Admission					
Labor medical specialists	1	234.07	234.07	Hospital database	Hospital database
Labor other personnel	1	246.73	246.73	Hospital database	Hospital database
Materials	1	59.47	59.47	Hospital database	Hospital database
Overheads	1	391.66	391.66	Hospital database	Hospital database
Inpatient stay (in days)					
Labor medical specialists	3.5	113.85	398.47	Hospital database	Hospital database
Labor other personnel	3.5	287.37	1005.81	Hospital database	Hospital database
Materials	3.5	31.87	111.55	Hospital database	Hospital database
Overheads	3.5	359.05	1256.67	Hospital database	Hospital database
Medication					
Paracetamol	4	0.13	0.53	Resident hand surgery	Medicijnkosten.nl
Oxycontin	2	0.17	0.34	Resident hand surgery	Medicijnkosten.nl
Oxinorm	6	0.10	0.61	Resident hand surgery	Medicijnkosten.nl
Medical aids					
Scotchcast	1	151.50	151.50	Hand surgeon	Orthopedic technician
Removable splint	1	252.50	252.50	Hand surgeon	Orthopedic technician
Night splint	1	555.50	555.50	Hand surgeon	Manufacturer
Inter physician communication					
Labor (in min)					
Hand surgeon	25	1.69	42.33	Hand surgeon	Hospital database
Rehabilitation specialist	10	1.69	16.93	Hand surgeon	Hospital database
Complications					
Lab application	17/39	14.12	6.16	Hospital database	Nederlandse Zorgautoriteit
Electrocardiography	1/39	22.35	0.57	Hospital database	Nederlandse Zorgautoriteit
Ultrasound arm	2/39	82.49	4.23	Hospital database	Nederlandse Zorgautoriteit
Histological research	1/39	59.26	1.52	Hospital database	Nederlandse Zorgautoriteit
Ultrasound bladder	8/39	82.49	16.92	Hospital database	Nederlandse Zorgautoriteit
Scotchcast	1/39	372.69	9.56	Hospital database	Orthopedic technician
Scotchcast	1/39	559.04	14.33	Hospital database	Orthopedic technician
Total costs of hospitalization			**4777.96**	**(SD 333.04)**	
Surgery					
Labor (in min)					
Hand surgeon	150	1.69	253.97	Hand surgeon	Hospital database
Resident hand surgery	180	0.56	101.05	Hand surgeon	Hospital database
OR assistant	420	0.57	238.28	Hand surgeon	Hospital database
Anesthesist	105	1.61	169.06	Hand surgeon	Hospital database
Resident anesthesiology	210	0.56	116.86	Hand surgeon	Hospital database
Surgery materials			201.03	Surgery center	Surgery center
General anesthesia			39.90	Hospital database	Anesthesist
Devices (in minutes)					
OR	210	0.03	7.14	Division Housing	Division Housing
Recovery	120	0.01	0.83	Division Housing	Division Housing
Overheads (in minutes)					
OR	210	0.84	176.75	Hand surgeon	Division Housing
Recovery	120	0.34	40.40	Hand surgeon	Division Housing
Total costs of surgery			**1345.26**	**(SD 91.73)**	
New scotschcast after admission (in 10% of the children)					
Labor (in minutes)					
Orthopedic technician	45	0.58	2.59	Hand surgeon	Hospital database
Overheads (in min)					
Plaster room	45	0.51	2.27	Hand surgeon	Division Housing
Scotchcast		151.50	15.15	Hand surgeon	Orthopedic technician
Total costs of new scotchcast after admission			**20.01**	**(SD 7.35)**	

(*Continued*)

Table 2. (Continued).

	Resource use	Unit costs	Costs per patient	Information source volume	Cost price
Checkup by multidisciplinary team					
Labor (in minutes)					
Hand surgeon	30	1.69	50.79	Hand surgeon	Hospital database
Resident hand surgery	30	0.56	16.84	Hand surgeon	Hospital database
Rehabilitation specialist	30	1.69	50.79	Hand surgeon	Hospital database
Occupational therapist	110	0.55	60.07	Occupational therapist	Hospital database
Overheads (in minutes)					
Outpatient clinic by multidisciplinary team	30	0.08	2.53	Hand surgeon	Division Housing
Outpatient clinic by occupational therapist	45	0.08	3.79	Occupational therapist	Division Housing
Devices (corrected for durability)					
AHA test	/ 5208	510.05	0.10	Occupational therapist and manufacturer	Occupational therapist
Box & Block test	/ 5208	285.97	0.05	Occupational therapist and manufacturer	Occupational therapist
Goniometer	/ 1562	45.45	0.03	Occupational therapist and manufacturer	Occupational therapist
Handheld dynamometer	/ 5208	338.35	0.06	Occupational therapist and manufacturer	Occupational therapist
Pinchmeter	/ 5208	292.90	0.06	Occupational therapist and manufacturer	Occupational therapist
Total costs of checkup by multidisciplinary team			**185.11**	**(SD 24.41)**	
Other checkups					
Labor (in min)					
Hand surgeon	30	1.69	50.79	Hand surgeon	Hospital database
Orthopedic technician	120	0.58	69.01	Hand surgeon	Hospital database
Rehabilitation specialist	15	1.69	25.40	Hand surgeon	Hospital database
Overheads (in min)					
Plaster room	120	0.51	60.60	Hand surgeon	Division Housing
Outpatient clinic by hand surgeon and rehabilitation specialist	30	0.08	2.53	Hand surgeon	Division Housing
Total costs of other checkups			**208.33**	**(SD 27.32)**	
TOTAL HOSPITAL COSTS			**6813.24**	**(SD 222.03)**	
Total costs of labor			**3417.16**	**(SD 209.44)**	
Total costs of overheads			**1946.45**	**(SD 363.51)**	
Total costs of medical aids			**998.54**	**(SD 214.31)**	
Total costs of materials and devices			**409.72**	**(SD 57.07)**	
REHABILITATION COSTS					
Physiotherapy (in h)	17.5	120.96	2116.82	Rehabilitation specialist	Standard prices
Occupational therapy (in 70% of the children)	17.5	120.96	1481.78	Rehabilitation specialist	Standard prices
TOTAL COSTS OF REHABILITATION			**3598.60**	**(SD 449.05)**	

term solution. Since surgery ensures a long-term clinical improvement of position,[14] surgery may be more cost-effective in the long term. Also performing a valid study comparing botulinum toxin and surgery would be difficult, as treatment selection strongly depends on the severity of the spasticity. Also no other treatments equivalent to surgery are available. Therefore, it was not possible to add a control group to our population.

Since CP is a disease with a wide range of clinical features, Park et al.[10] stated that healthcare cost should be considered in light of the physiological types and extent of involvement. Our study population is as homogenous as possible. Patients included had the same type of spasticity, similar extent of gross motor function, same aim of surgery, and no traumatic injuries to or prior surgical intervention on the operated arm. Such a specific patient group and the infrequent execution of this surgery results in a small study population, which is a limitation. The multidisciplinary team of the AMC in Amsterdam performs almost half of all the upper-extremity surgeries in children with CP in the Netherlands. This is the reason the study was performed in only one hospital, and interviews were held only with one person per profession. Because of the infrequent performance of the surgery, the study population was included from April 2003 until April 2008. However, as the results are presented as transparently as possible (Table 2), researchers may adjust estimations of resource use and unit costs to their own specific setting when desired. Moreover, the sensitivity analysis demonstrated the robustness of the results. Although this study was conducted in a single Dutch hospital, we thus believe that our findings could be representative of other hospitals and other countries, especially those in which the general practitioner operates as the gatekeeper of specialist health care.

Table 3. Sensitivity analysis.

	Variation unit cost value		% change in total costs when unit cost value varied by 50%	% change in hospital costs when unit cost value varied by 50%
	50%	150%		
Labor	1708.58	5125.74	16.41	25.08
Overheads	973.23	2919.68	9.35	14.28
Medical aids	499.27	1497.81	4.80	7.33
Materials and devices	204.86	614.58	1.97	3.01

This article is the first that describes the costs of the surgical correction of upper limb deformity in children with spastic CP. We conclude that hospital costs for this surgery are the most important contributor to the healthcare costs of a child with CP (€6813). Labor accounts for the highest cost; therefore to reduce costs, effective use of hospital staff is important. Furthermore, rehabilitation costs after this surgery are substantial (€3599). This emphasizes the importance of taking follow-up costs into account when calculating costs of a musculoskeletal surgical intervention.

Our study has demonstrated the importance of evaluating health care costs of children with CP, which are higher than average.[8–10,22] To gain more insight into the total health care costs of children with CP, further research is needed on costs of other treatments for children with, also other types of, CP. Furthermore, it is desired to weight costs against clinical parameters, providing hospital managers, insurance companies, and policy makers with valuable information on the relative efficiency of alternative options.

Declaration of interest

The authors report no declaration of interest.

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